SWOT Virtual Mission over Arctic river basins

S. Biancamaria[1] (sylvain.biancamaria@legos.obs-mip.fr), P. Bates[2], A. Boone[3], N.M. Mognard[1], M. Durand[4], K. Andreadis[5], E. Rodriguez[6], D.E. Alsdorf[4], D. Lettenmaier[5], F. Frappart[7]

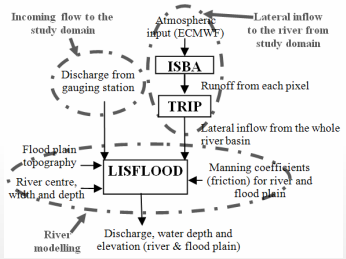
[1] LEGOS, FR [2] University of Bristol, UK [3] CNRM/GAME, FR [4] Ohio State University, USA [5] University of Washington, USA [6] JPL, USA [7] LMTG, FR

Purpose of the study

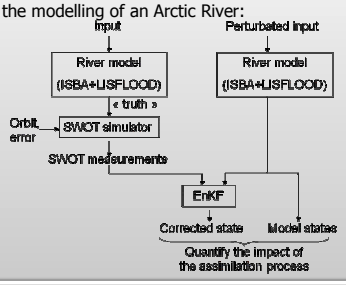
- The Surface Water Ocean Topography (SWOT) mission is a wide swath altimeter, with two 60 km swaths (with 10m to 70m across track resolution and 5m along track resolution). It will measure surface water elevation.
- The aim of this work it to implement a SWOT virtual mission over Arctic rivers, i.e. assess how the SWOT mission will improve our understanding and our ability to model Arctic rivers.

Methodology & Studied rivers

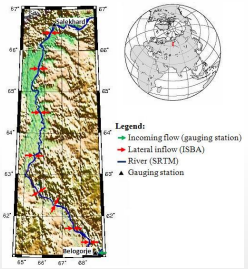
- River is modelled by coupling hydrologic (ISBA) and hydraulic (LISFLOOD-FP) models:



- Sketch of the SWOT Virtual Mission to assess how a wide swath altimeter could improve the modelling of an Arctic River:

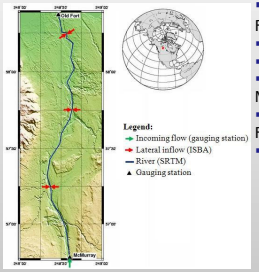


- The Ob river in Siberia:



- Ob modelled between 2 gauges at Belogorje and Salekhard before the Ob mouth.
- Modelled river legnth~900km
- Study domain area is 333x417=138,861 km^2.
- Incoming flow from in-situ data (at Belogorje).
- As validation, modelled discharge at Salekhard compared to in-situ measurements.
- LISFLOOD input:
  - floodplain topography = ACE (Altimeter Corrected Elevation, resolution: 1km)
  - river center and width from CIA WDB II
  - constant river depth
  - constant Manning coefficient

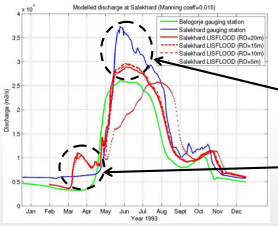
- The Athabasca river in Canada:



- Athabasca modelled between the 2 gauges at Fort McMurray and Old Fort.
- Modelled river legnth~200km
- Study domain area is 60x178=10,680 km^2.
- Incoming flow from in-situ data (at Fort McMurray).
- As validation, modelled water elevation at Old Fort compared to in-situ measurements.
- LISFLOOD input:
  - floodplain topography = SRTM (resolution: 90m)
  - river center from SRTM
  - river width from in-situ measurements
  - constant river depth
  - constant Manning coefficient

Results for the Ob river

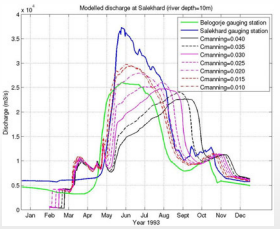
(a) Variations of river depth (5m, 10m, 15m and 20m), Manning coefficient (0.015)



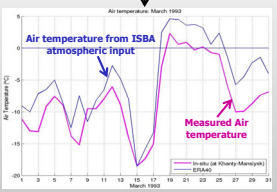
Modeled discharge underestimated : atmospheric input precipitation is too weak

Unrealistic discharge peak

(b) Variations of Manning coefficient (0.01, 0.015, 0.02, 0.025, 0.03, 0.035 and 0.04), river depth (10m)



(c) Comparison ISBA atmospheric air temperature and in-situ measurement near Belogorje : late March warming from atmospheric input (ERA-40) too high: ISBA early snow melt (unrealistic discharge peak in March)

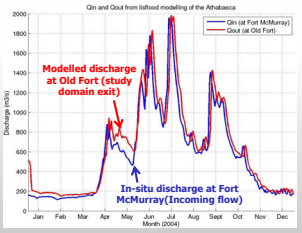


(d) Nash-Sutcliff, correlation coefficients and RMSE between modelled and in-situ discharge at Salekhard and comparison with 22 water elevation time series over the lower Ob from Topex-Poseidon show the best modelling is obtained when using a river depth of 10m and a Manning coefficient of 0.015.

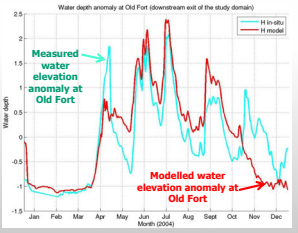
(e) Sensitivity tests on the LAI (Leaf Area Index) and the Green Fraction cover (from Ecoclimap and from University of Wales) show little impact of this parameters on the modelled discharge.

Results for the Athabasca river

(a) Comparison input discharge (blue curve, in-situ measurement at Fort McMurray) to the study domain and modelled discharge at Old Fort (red curve) -> weak lateral inflow from ISBA



(b) Comparison modelled (red curve) and in-situ (cyan curve) water elevation **anomaly** at Old Fort. Anomaly is used, as absolute elevation at the gauge is not known. Globally good timing between modelled and in-situ anomaly, yet some precipitation events are not well modelled (especially in November). Most of them are underestimated (due to weak ISBA lateral inflow).



Conclusions & Perspectives

- Two arctic rivers, at different scales, have been modelled.
- On the lower Ob river, comparisons between modelled output and in-situ measurements and Altimetry, allows to accurately modelled the discharge at the exit of the study domain. Yet precipitation from the atmospheric input are too weak, leading to an underestimated modelled discharge. The input air temperature is too high leading to an early snowmelt and thus to unrealistic peak in the modelled discharge. The next step will be to compute a (precipitation and temperature) corrupted ensemble of the modelling, used in the EnKF to estimate model error. Then SWOT observation will be generated and assimilated.
- The Athabasca modelling needs further validation and sensitivity tests, but the preliminary results seem encouraging.